A Test to Illustrate the Effects of BioSolve on the Mobility of the Oil in Contaminated Soils

May 27,1999

Final Report
Phase I and 11

Prepared for:

Mountain States BioSolve
4219 Whitney Road
Cheyenne, Wyoming 82001
(307) 634-3245

Prepared by:

Rocky Mountain Oilfield Testing Center
907 N. Poplar, Suite 150
Casper Wyoming 82601
(307) 437-9620

PREFACE

BioSolve manufactures products for insitu bioremediation projects and has the ability to desorb and emulsify the hydrocarbon in the substrate. When applied through injection wells, BioSolve allows the microbe to metabolize the contaminate by stripping the hydrocarbon off the soil particles and emulsifying it into the pore space creating a large interfacial surface area.

BioSolve is a blend of water-based, biodegradable surfactants which were engineered as a clean-up and mitigation agent for use on hydrocarbon products.

BioSolve does not cause or catalyze specific chemical reactions, nor does it contain any bacteria cultures. The basic principle is to emulsify the hydrocarbon into small encapsulated particles in a water/oxygen bearing solution. This process desorbs the hydrocarbon molecules from the soil particles and allows the bacteria to rapidly metabolize the contaminate.

The surfactants desorb or strip the hydrocarbon from the soil particles during the emulsification process. During the desorption process it is expected that the Total Petroleum Hydrocarbons (TPH) levels will increase shortly after application. This is due to the contaminate emulsifying off the soil particle and increasing the total recoverable hydrocarbon.

This allows the hydrocarbon, in the pump and treat process, to become mobile, and carried with the water to the recovery wells where it can be removed. This testing does not address pump and treat technology but only the increased surface area for bioremediation enhancement.

In bioremediation projects, shortly after the TPH increase, there will be a dramatic decrease in the TPH levels.

INTRODUCTION

Mountain States BioSolve of Cheyenne, Wyoming contracted with Rocky Mountain Oilfield Testing Center (RMOTC) of Casper, Wyoming to conduct a bench test. The test was intended to illustrate the mobility of crude oil in soils on which we apply BioSolve as a surfactant to enhance the bioremediation of hydrocarbons from contaminated soils.
Wyoming Oil and Gas Conservation Commission (WOGCC) referred Mountain States BioSolve to RMOTC. It is the purpose of WOGCC to ensure that any products applied to soils do not increase the amount of petroleum hydrocarbons entering the ground water in the area on which it is applied.

The procedures detailed in this report are based on earlier testing conducted by RMOTC. RMOTC used clean soil samples. The bench test was conducted onsite at the Naval Petroleum Reserve No. 3. Mountain States BioSolve provided samples of BioSolve to RMOTC.

The data presented in this report was collected from February 22, 1999 to March 5, 1999.
This report will detail the materials and methods used to conduct the test, test procedures, laboratory results, and conclusions.

Materials and Methods

Experimental Design

To simulate the flow of water through the soil, previously constructed tubes were used to hold columns of soil. Two tubes were used to conduct two sets of tests. (See Figure 1).

Figure 1

Each tube was constructed from 4 inch diameter piece of schedule 40 clear PVC pipe, 36 inches in length. At the bottom of each tube a one-half inch outlet valve was inserted. One-half inch holes were drilled at six inch intervals along the length of the pipe. One-half inch pipe plugs were installed into the holes. (See Figure 2)

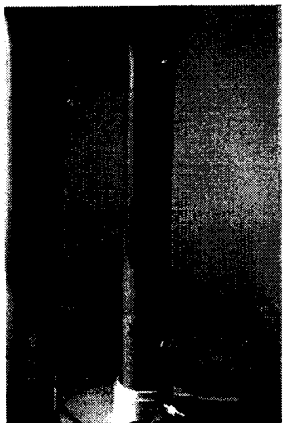

Figure 2

The tubes were set into specially constructed stands. The control tube was labeled as #1 and the test tube was labeled as #2. Eight inches of medium grain clean sand was loaded into the tubes. Twenty-four inches of clean sandy-loam dirt was loaded on top of the sand. Four inches of head space was left to accommodate the addition of oil, water and BioSolve. One thousand milliliter glass jars were placed below the outlet valve of each tube. (See Figure 3)

Unrefined sweet crude oil (36' API) was collected from an onsite battery. The oil and tubes, loaded with soils, were allowed to sit overnight in order to reach ambient room temperature.

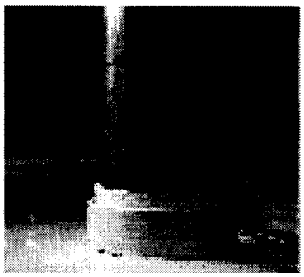

Figure 3

Experimental Procedure

The experiment was divided into two phases. Two tubes were used in each phase. Tube #1 was the control tube and Tube #2 was the test tube. A measured amount of oil and water was added to each tube. BioSolve was added to Tube #2 only. After collecting the output fluid from each tube, they were allowed to set for four days before soil samples were collected.

Tube# 1 -Phase 1, February 22, 1999

Sand and soil were added to the tube as described above. Temperatures were taken of the soil and unrefined crude oil prior to the addition of any fluids. The soil temperature was 75F. The unrefined crude oil was 71 'F. 200 milliliters of unrefined crude oil was added to the tube, then 1000 milliliters of tap water at 120F was added to the tube. All of the water was absorbed in less than one hour. We began collecting leachate from the tube. An additional 1000 milliliters of tap water at 120F was added one and one-half hours after the test began. This water was observed to be completely absorbed within one hour. Less than seven hours later, we collected a total of 1270 milliliters of leachate. This sample was taken to Energy Laboratories and 1230 milliliters of leachate was analyzed for TPH

content. The sample contained <1.0 mg/L (EPA Method 418. 1). (See Table 1)

Tube #2 - Phase 1, February 22, 1999

Sand and soil were added to the tube as described above. Temperatures were taken of the soil and unrefined crude oil prior to the addition of any fluids. The soil temperature was 76F. The unrefined crude oil was 71 'F. 200 milliliters of unrefined crude oil was added to the tube, then a mixture of 1000 milliliters of tap water at 123F and 250 milliliters (20% BioSolve) of BioSolve was added to the tube. Only three inches of water was absorbed in the first 30 minutes of the test. An additional 640 milliliters of tap water at 120F was added one and one-half hours after the test began. (Note: we could only add this amount of water to this tube due to the slow absorption of fluid.) Six hours later the remaining 360 milliliters of water (at 120F) was added to the tube. No leachate was collected on the first day of the Phase I test.

On the second day, four inches of fluid had been absorbed overnight although no leachate had collected in the catchment jar. By the end of the second day, 550 milliliters of leachate had been collected. By the morning of the third day, an additional 400 milliliters of leachate was recovered. This sample was taken to the lab and 860 milliliters of leachate was analyzed for TPH content. The sample contained <1.0 mg/L. (See Table 1)

Soil Samples

Four days after the test began the plugs along the length of the columns were removed to collect soil samples. Samples were taken from the top, and each six inch interval thereafter. The samples were transported to Energy Laboratories to be analyzed for total petroleum hydrocarbons. (See Table 4 and Figure 6)

Tube #1 - Phase II, March 1, 1999

Sand and soil were added to the tube as described above. Temperatures were taken of the soil and unrefined crude oil prior to the addition of any fluids. The soil temperature was 73F. The unrefined crude oil was 71F. 200 milliliters of unrefined crude oil was added to the tube, then 1000 milliliters of tap water at 140F was added to the tube. Again, all of the water was absorbed in less than one hour. We began collecting leachate from the tube. An additional 1000 milliliters of tap water at 138F was added one and one-half hours after the test began. This water was observed to be completely absorbed within one hour. Less than seven hours later, we collected a total of 1190 milliliters of leachate.

This sample was taken to the lab and 930 milliliters of leachate was analyzed for TPH content. The sample contained <1.0 mg/L.

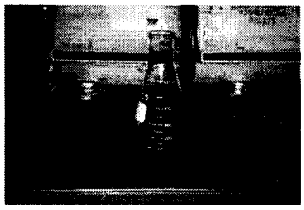

Figure 4

Tube #2 - Phase II, March 1, 1999

Sand and soil were added to the tube as described above. Temperatures were taken of the soil and unrefined crude oil prior to the addition of any fluids. The soil temperature was 73 'F. The unrefined crude oil was 71 'F. 200 milliliters of unrefined crude oil was added to the tube, then a mixture of 1000 milliliters of tap water at 141F and 120 milliliters (10% BioSolve) of BioSolve was added to the tube. This water was absorbed within the first hour of the test. An additional 950 milliliters of tap water at 140F was added one and one-half hours after the test began. Three hours later, approximately 200 milliliters of fluid had collected in the catchment jar. An hour later we added the remaining 50 milliliters of tap water to the column. A total of 780 milliliters of fluid had collected by 1430 hrs. The following morning an additional 140 milliliters of fluid had collected. This sample was taken to the lab and 910 milliliters of leachate was analyzed for TPH content. The sample contained 1.7 mg/L. (See Table 2)

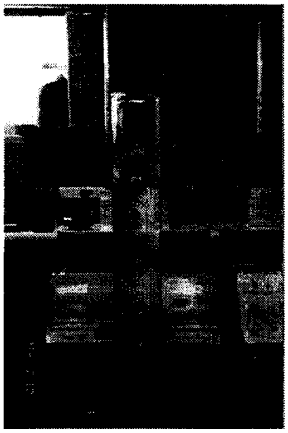

Figure5

Soil Samples

Four days after the Phase 11 test began the plugs along the length of the columns were removed to collect soil samples. Samples were taken from the top, and each six inch interval thereafter.The samples were transported to Energy Laboratories to be analyzed for total petroleum hydrocarbons. (See Table 4 and Figure 7)

Conclusion

This test was conducted to illustrate the mobility of crude oil in soil on which BioSolve is applied as a surfactant. The BioSolve solution was tested at a 10% concentration and 20% concentration. In comparison to the untreated tube it was not clear that BioSolve would in fact lower the level of total petroleum hydrocarbons in the soil based on results from this test. This may be due to the emulsification of the contaminate off of the soil particle thereby increasing the total recoverable hydrocarbon detected during lab analysis. However both tests demonstrated that BioSolve does retard the rate of saturation and movement of fluid through the soil column up to four times the rate of the untreated columns. This slower saturation rate may allow sufficient time for bacteria to metabolize the contaminates thus reducing the levels of total petroleum hydrocarbons in the soil.

Phase I Results		
Leachate Only	Volume (mL)	TPH Results, mg/L 20% BioSolve solution
Tube #1	1230	<1.0
Tube#2	860	<1.0

Phase 11 Results		
Leachate Only	Volume (mL)	TPH Results, mg/L 10% BioSolve solution
Tube #1	930	<1.0
Tube #2	910	1.7

Table 2

Phase I Soil Only	Tube #1 Volume, mL	Weight, 9	TPH Results mg/Kg	Tube #2 Volume, mL	Weight, 9	TPH Results mg/Kg 20% BioSolve solution
Top	100	10	29,900	100	10	25,900
24”	100	10	43,300	100	10	10,300
18”	100	10	10,600	100	10	20,300
12”	100	10	34	100	10	18,600
6”	100	10	41	100	10	1,220
Bottom	100	10	34	100	10	42
Phase 11 Soil Only	Tube #1 Volume, mL	Weight, 9	TPH Results mg/Kg	Tube#2 Volume, mL	Weight, 9	TPH Results mg/Kg 10% BioSolve solution
Top	100	10	64800	100	10	74900
24"	100	10	42000	100	10	64600
18”	100	10	8100	100	10	19500
12”	100	10	30	100	10	14100
6”	100	10	<10	100	10	<10
Bottom	100	10	<10	100	10	<10

Table 3

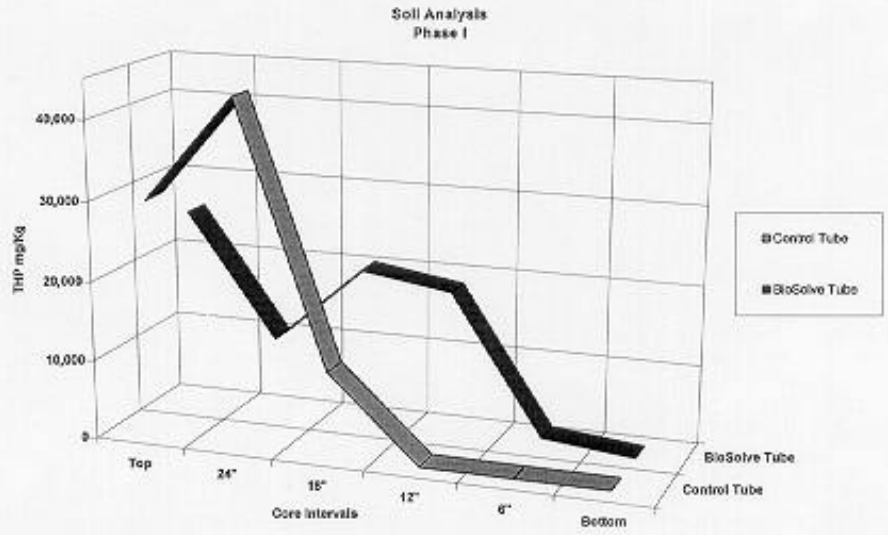

Figure 6

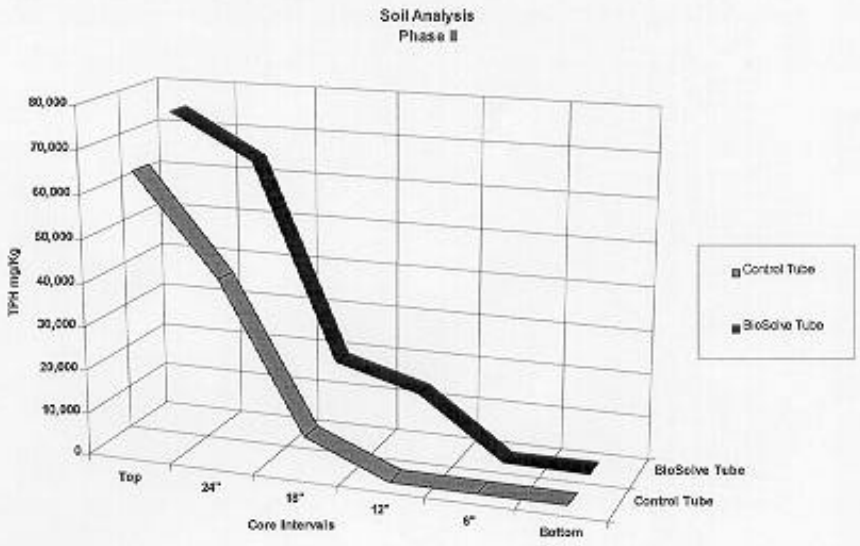

Figure 7